How have land uses changed in the South, and how might changes in the future affect the area of forests?

Chapter 6: Land Use

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Key Findings

■ Except for a moderate decline in agricultural uses, most States in the South have experienced relatively stable land use distributions between 1945 and 1992. The most notable exception is Florida, where developed land uses have expanded substantially.

■ Stability in overall land use distributions masks offsetting shifts into and out of forest cover in many States.

■ Urbanization and relative returns to agriculture and timber uses will strongly influence changes in land use during the next 20 years. Urbanization will continue to consume forest land and agricultural land, while rising timber prices will push some agricultural land toward forest uses.

■ The South is forecast to lose 12 million forest acres (8 percent) to developed uses between 1992 and 2020. An additional 19 million forest acres are forecast to be converted to developed uses between 2020 and 2040.

■ Southern forest losses will likely be concentrated in a few places: (1) the Piedmont and Mountain areas of North Carolina, (2) adjacent Piedmont areas of South Carolina and Georgia, (3) Florida, and (4) the Atlantic and gulf coastal areas. Smaller areas with substantial projected losses include areas surrounding the cities of Nashville, TN, and Birmingham, AL, and the area of northern Virginia between Washington, DC, and Richmond, VA.

■ Increased timber prices are forecasted to cause about 10 million acres of agricultural land to be forested between 1992 and 2020. As much as 25 million acres of agricultural land could be forested by the year 2040.

■ Much agricultural land may be converted to forest in some parts of the South. In the eastern part of the South, gains are possible on the upper Coastal Plain of Georgia and on the Coastal Plain in an area centered on the boundary between North Carolina and Virginia. The largest area of potential forest gains is on the lower Gulf Coastal Plain and in large portions of Arkansas, Mississippi, and Louisiana.

■ Taken together, these forecasts suggest a western shift in forest area—losses are concentrated in the eastern South, and gains are concentrated in the western South.

■ Forecasts of a forest population density index indicate that the potential influence of southern urban areas extends far beyond their cores. This condition has important consequences. As the population increases in a forested area, the ability of the forest to moderate microclimate may be reduced. Availability of land for public recreation is normally reduced, and availability for timber management plummets.

■ In some areas, the share of forest cover is relatively high, but forest tracts are highly fragmented. This condition is prevalent in some northern parts of the South, on the Southern Appalachian Piedmont, and in northern Florida. In these areas, marginal changes in the amount of forest cover may have disproportionate impacts on the connectivity of forested habitats.

Introduction

Three major periods characterize land use in the South: (1) the era of agricultural exploitation, (2) the era of timber exploitation, and (3) the era of recovery and renewal. Agricultural exploitation started in the 17th century but reached its zenith in the late 19th century, when a vast cotton industry stretched from the Atlantic to Texas. Other crops supplanted cotton as the boll weevil ran its course, and all have had influence on the land. Timber exploitation, which peaked in the first part of the 20th century, had its roots in the disposal of a large public domain in the years immediately after the Civil War (Williams 1989). The timber industry migrated to the South after timber stocks were depleted in the Lake States, and 20 years of extensive timbering left southern timber stocks similarly depleted. By the start of the Great Depression, intensive agriculture and timbering had seriously degraded the land. Farms were abandoned, and forests were reestablished and renewed over the next 40 years.

Currently, a different set of forces is shaping southern forests. Strong economic growth has fueled increased population and urbanization (Alig and Healy 1987). In addition, relative changes in agricultural and timber markets strongly influence the allocation of rural land to agricultural and forest uses (Alig 1986). Agriculture's returns have generally declined relative to forestry, and the South has become the dominant timber-producing region in the country. More than 58 percent of domestic fiber production in 1997 was from the South. Returns to agriculture and forestry vary widely depending on land quality, climate, and location relative to markets. Where agriculture does not dominate and conditions are conducive, much land is actively and intensively managed for timber production. As a result, the South is now the largest agricultural-style timber-producing region in the World.

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This chapter describes historic, current, and probable future land use in the South. It identifies the forces that have shaped, and will continue to shape, forest area. It focuses on the relative roles of population change, economic growth, agricultural markets, and timber markets as they interact to define the values of land in different uses. This chapter also examines how increasing populations and development influence the landscape structure of forest landscapes.

Methods

Historical Land Use

Areas in various land uses were obtained from Federal and State agencies. Records of land use before World War II are somewhat spotty, but land use records at the State level have been compiled at irregular intervals since 1945. The most recent of such surveys was conducted in 1992. The U.S. Department of Agriculture Economic Research Service (1996) has constructed a database of areas in major land uses for the period 1945 to 1992 at about 5-year intervals. This database corrects for differences in land use definitions in the various surveys.

We examine shares of each land use by State over this time period. We were also able to examine State-level land use changes between 1982 and 1997 using a different dataset. The 1997 data are the most recent comprehensive measures of land use available.

In addition to these long-run data compiled at the State level, we summarized land use changes for individual counties and for ecological sections between 1982 and 1992. While limited to a shorter period, these data provide a picture of the spatial pattern of land use change.

Land Use Forecasts

To forecast land use change to 2020, we employed a county-level model developed by Hardie and others (2000). This econometric model assumes that:

- The allocation of land between urban and rural uses is driven by population density, personal income, and housing values.
- The allocation of rural land to agricultural and forest uses is driven by returns to local crops, returns to grazing, agriculture costs, land quality, and timber prices. All of these variables except timber prices are defined at the county level of resolution. Timber prices are defined for two or three subregions per State defined by the Timber Mart South price reporting service.

The model was estimated based on land use patterns recorded in 1982, 1987, and 1992 by the National Resource Inventory (NRI) [see Hardie and others (2000) for modeling details]. Detailed land use categories were lumped into four classes: urban/residential, cropland/pasture, forest, and other. The urban/residential class includes areas in transportation and other corridors. The other class can be considered a transitional zone where land use is unclear due to changing conditions.

Before land uses could be projected, we had to forecast the factors that drive changes. Accordingly, we acquired county-level forecasts of population density and personal income and developed forecasts of housing values.

Two core projections were developed to (1) isolate the influence of general economic and population growth on the region and (2) completely assess land use changes that account for market responses to increased scarcity of timber as rural land is developed. The two core projections were defined for the following scenarios:

Urban growth scenario—An initial scenario was developed assuming that the population, income, and housing value forecasts are correct and that the relative positions of timber and agricultural markets do not change in the future. Effects of population growth and economic growth on urban land uses are estimated.

Base scenario—A scenario was also constructed to evaluate how rural land uses might be influenced by a relative shift in returns to agricultural and timber management. This scenario assumes that the population and economic change forecasts in the urban growth scenario hold and that the real price of softwood timber will increase by 35 percent by 2020, consistent with timber market forecasts developed in chapter 13. Agricultural returns are held at their 1992 levels. This scenario was built by imbedding the land use model described here within the timber market model as described in chapter 13. This procedure allowed land use, timber management, timber harvesting, and timber prices to be jointly and consistently determined. [See chapter 13 for a detailed description of modeling assumptions with respect to timber productivity, timber demand, and other factors. See Murray and others (2001) for a description of how these models are linked together.]

A sensitivity analysis was conducted to see how land uses would be affected by different forecasts for timber and agricultural prices. Results show where rural land use may be most sensitive to timber market changes in the South.

The histories of key driving variables were analyzed. Population changes in counties were plotted. Changes in timber and agricultural prices over time were also analyzed.

Forest Conditions

Forest population density—To examine the potential influence of the expanding wildland-urban interface on forests of the region, we construct a simple index. For each county in the South, we divide the number of people by the area of forest in square miles. The resulting forest population density index (FPD) provides a measure of the population pressure on existing and future forests. For example, a high FPD indicates a relative scarcity of forest benefits for people in the county.

Clearly, FPD is a very general measure of human influence, but it helps to define where population effects on forests may be most concentrated and where they may change most in the future. Forecasts of the FPD to 2020 were constructed from population and land use forecasts.

Landscape pattern—Measuring the configuration of forests in a county requires spatially explicit data. The basis of the analysis was a fine-scale (0.09 ha) grid-based map of landcover in each county developed from satellite images of the South. Each 0.9-ha cell is called a pixel.

A forest fragmentation indicator was constructed from the landcover maps as defined by Riitters and others (2000). Landcover was lumped into forest and nonforest classes, and the index was calculated based on the amount and connectivity of forest pixels within a fixed area around each pixel. The "forest" class included shrubland, woody wetland, and three upland forest types on the landcover maps. A value representing the forest fragmentation indicator was assigned to the center pixel. The pixel value thus describes the forest fragmentation condition within which that pixel of landcover occurs. Forest fragmentation values were constructed for two different neighborhood sizes: 7 ha (17 acres) and 66 ha (163 acres). Six forest fragmentation classes were defined:

1. Perforated—Most of the pixels in the surrounding area are forested, and this pixel appears to be part of an inside edge of a forest patch. In other words, this pixel is near a nonforest inclusion within a forest.

2. Edge—Most of the cells in the surrounding area are forested, and this cell appears to be part of the outside edge of a forest patch.

3. Transitional—About half of the pixels in the surrounding area are forested, and this pixel may appear to be part of a patch, edge, or perforation depending on the local forest pattern.

4. Patch—Most of the pixels in the surrounding area are not forested, and this pixel is part of a forest inclusion or patch of forest on a nonforest background.

5. Interior—All of the pixels in the surrounding area are labeled as forest in the landcover map.

6. Nonforest—Essentially none (less than 0.5 percent) of the pixels in the surrounding area are labeled as forest in the landcover map.

Cells labeled water or with missing values were excluded, and data were summarized for counties and ecological sections. Fragmentation was summarized in two ways: (1) the share of area that is interior forest as defined above and (2) the share of edge-dominated forest, defined by summing the shares of area in edge, transitional, and patch categories. This scheme leaves out the perforated category, which may indicate an intensively managed forest area, but is neither interior forest nor clearly edge-dominated.

Data Sources

Historical Land Use

Land use databases: major land uses database—This database contains land uses by major category for each Census of Agriculture year (roughly every 5 years) between 1945 and 1992. The database was constructed by the U.S. Department of Agriculture Economic Research Service. To document general trends in land use for the South, we report data for the 11 entire Southern States within the region. Texas and Oklahoma are excluded because only small portions of these States are in the Assessment area, and the portions not included have very different ecological conditions. Including totals for Texas and Oklahoma therefore would significantly skew the results.

We report land uses by the following categories:

1. Cropland—This category includes cropland harvested, crop failure, cultivated summer fallow, cropland used only for pasture, and idle cropland.

2. Pasture—This category includes all open land used primarily for pasture and grazing. Forested pasture is included under forest land.

3. Forest land—This category is generally consistent with U.S. Department of Agriculture Forest Service definitions of forest. It includes land at least 10-percent stocked by trees of any size and land formerly having had such tree cover that will be naturally or artificially regenerated. These data are not necessarily consistent with Forest Service estimates of forest land area due to differences in classification of dominant land use. In spite of these differences, estimates provide a useful means for examining regional trends in forest area consistent with changes in other land use categories.

4. Urban plus rural transportation—Urban areas are incorporated and unincorporated places of 2,500 or more people. Rural transportation corridors include highways, roads, and railroad rights-of-way, plus airport facilities.

5. All other—The difference between categories 1 through 4 and total land area.

Land use databases: National Resource Inventory—The NRI is a multiresource inventory conducted on non-Federal lands by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS). The NRI was conducted in 1982, 1987, 1992, and 1997. The inventory uses a statistically based sample of plots with information compiled on landcover or use, wetlands, habitat diversity, etc. We report land use data aggregated to the county and the ecological section levels.

Definitions of land use categories are somewhat different from those used in the Land use databases: major land uses database described earlier. We report NRI land uses by the following four categories:

1. Agriculture: cultivated and uncultivated cropland plus pasture.

2. Forest land: area that is "at least 10 percent stocked by single-stemmed woody species of any size that will be at least 4 meters tall (13 feet) at maturity. Also included is land bearing evidence of natural regeneration of tree cover and not currently developed for nonforest use" (National Cartography and Geospatial Center 1998).

3. Urban and built-up areas. "A landcover category consisting of residential, industrial, commercial, and institutional land; construction sites; public administrative sites; railroad yards;" etc., as well as tracts of less than 10 acres that "are completely surrounded by urban and built-up land" (National Cartography and Geospatial Center 1998).

4. Other: Defined here as total non-Federal land minus the area in categories 1 through 3.

Driving variables: population and personal income—Historical data were taken from the U.S. Census and arrayed at the county level. Forecasts of population and personal income were the baseline projections developed for the U.S. Assessment of Possible Vulnerabilities to Climate Variability and Change (NPA Data Services, Inc. 1999).

Driving variables: agricultural land rents—Statewide annual land rent data for the period 1960 to 1994 were taken from a database compiled by the U.S. Department of Agriculture Economic Research Service. Farmland rent is defined as the difference between revenues and total variable costs for both crop and pasture uses. The rents per acre per farm were adjusted for inflation by the gross domestic product price deflator.

Driving variables: timber prices—Rents for forest management directly comparable to the agricultural rents described above are not available in the South. To index the relative returns to forest uses, we examined real stumpage prices for sawtimber and pulpwood from Louisiana for the period 1960 to 1996. These are the only consistently measured stumpage prices available in the South for this extended period. The source of the data is Louisiana severance tax records reported by Ulrich (1987) for 1950 to 1965 and by Howard (1999) for 1966 to 1996. Units are dollars per thousand board foot Scribner for sawtimber and dollars per cord for pulpwood.

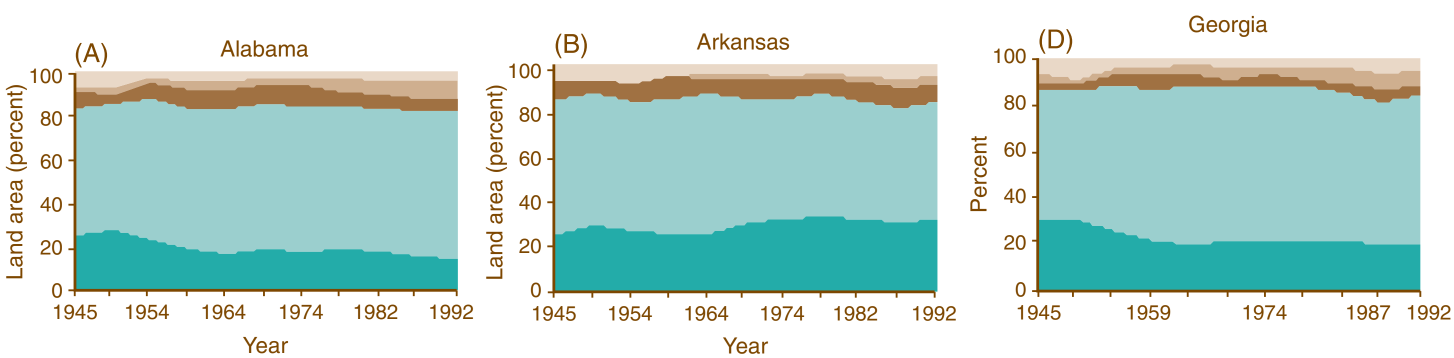
Table 6.1—Allocation of southern land among major uses, 1945-92[a]

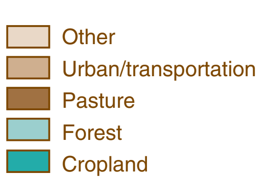
Year	Cropland	Forest	Pasture	Urban[b]	Other
			Percent		
1945	25.1	54.6	8.0	2.1	10.1
1949	26.7	55.9	6.0	2.5	8.9
1954	24.2	57.6	8.1	2.6	7.5
1959	21.6	58.1	10.3	3.2	6.7
1964	20.5	60.0	9.6	3.6	6.3
1969	23.1	58.1	8.2	3.8	6.8
1974	23.1	57.9	7.9	4.3	6.9
1978	23.7	57.0	6.2	5.3	7.8
1982	22.9	55.7	7.3	5.8	8.3
1987	21.7	55.4	7.2	6.6	9.1
1992	21.5	56.2	6.7	6.6	9.0

[a] Values for Texas and Oklahoma are not included.
[b] Urban includes transportation corridors.

Forest Area Conditions

Landscape patterns: Multi-Resolution Land Characteristics (MRLC) landcover maps—The MRLC consortium (Loveland and Shaw 1996) has developed landcover maps with a consistent interpretation protocol for the entire South. The MRLC protocol (Vogelmann and others 1998) combines Thematic Mapper (satellite) imagery from the early 1990s with other spatial databases to map landcover at a spatial resolution of 0.09 hectares per pixel. Thirteen State maps were obtained from the MRLC database and combined for this analysis. The maps for three of the States (Arkansas, Oklahoma, and Texas) were in draft form at the time of this analysis (December 2000). The parts of Oklahoma and Texas outside the Assessment area were excluded from the analysis. The landcover maps were summarized for the original 21 landcover types and also for a lumped 8-class version of the map. Lumped categories are: (1) water, (2) developed/urban, (3) barren/disturbed, (4) forest, (5) shrubland, (6) agriculture, and (7) grassland.





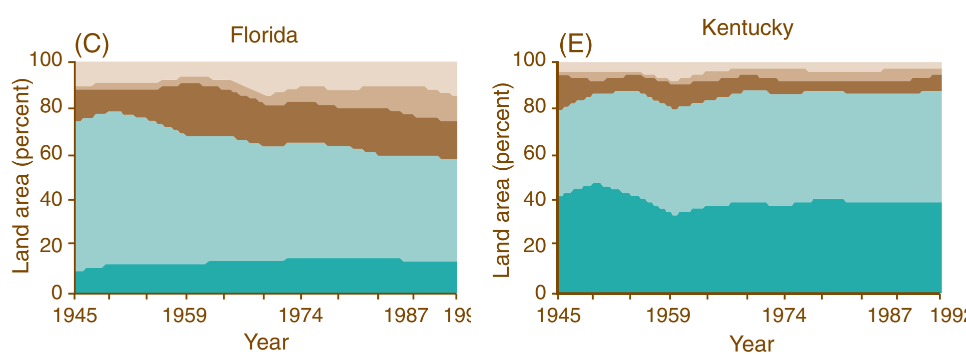


Figure 6.1—Land use shares by type for Southern States, 1945 to 1992 (Texas and Oklahoma are not included) [major land use database (Economic Research Service 1996)].

Results

Historical Land Use

State-level land use changes—Between 1945 and 1992, two major changes in land use occurred: (1) the area of urban and rural transportation uses roughly tripled, from 2.1 to 6.6 percent of land area, and (2) agricultural uses declined. This finding is consistent with population growth observed over the same period. Total agricultural uses (cropland plus pasture) declined from about 33 percent in 1945 to about 28 percent in 1992 (table 6.1). In contrast, forest area has been roughly constant. It was about 56 percent of the South in 1992 and ranged from a low of 55 percent in 1945 to a high of 60 percent in 1964.

Trends varied considerably among States (fig. 6.1). In Florida, area of forest declined from 66 percent of the land area in 1945 to 45 percent in 1992. Between 1945 and 1974, the area of land in agriculture increased steadily. Since 1974, growth in urban uses and rural transportation uses has dominated. In 1945, 3 percent of Florida was in human-dominated use; by 1992, that area had risen to 12 percent.

Georgia, Alabama, Tennessee, Kentucky, and the Carolinas all experienced declines in agricultural land uses from 1945 to 1964, with compensating gains in forest land. Other States had relatively stable agricultural area over this period. In all States, forest is the dominant land use, but the degree of dominance has changed in many States (fig. 6.1).

The pattern of change for forest land also differs among States. With the exceptions of Arkansas, Florida, and Louisiana, all States had more forest land in 1992 than they did in 1945. In the eight States with gains, land use shifted strongly from agriculture to forest between 1945 and 1969. Georgia, North Carolina, and Virginia have experienced declines in forest area since the early seventies. Over the same period, area in forest has been essentially stable in Alabama, Kentucky, Mississippi, South Carolina, and Tennessee.

Data from the NRI provide the most recent measures of land use change in the United States. The predominant pattern of change between 1982 and 1997 has been an erosion of the total area of cropland and an increase in the area of developed uses. The total area of pasture and forest declined only slightly between 1982 and 1997 (fig. 6.2). Most of the urban land uses and

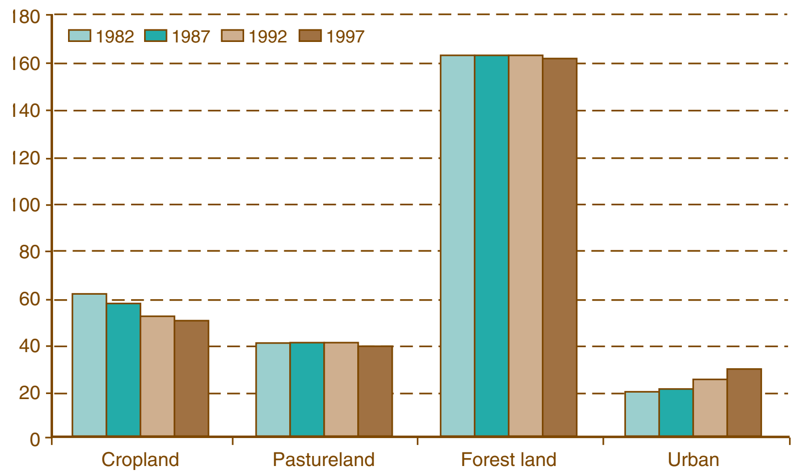
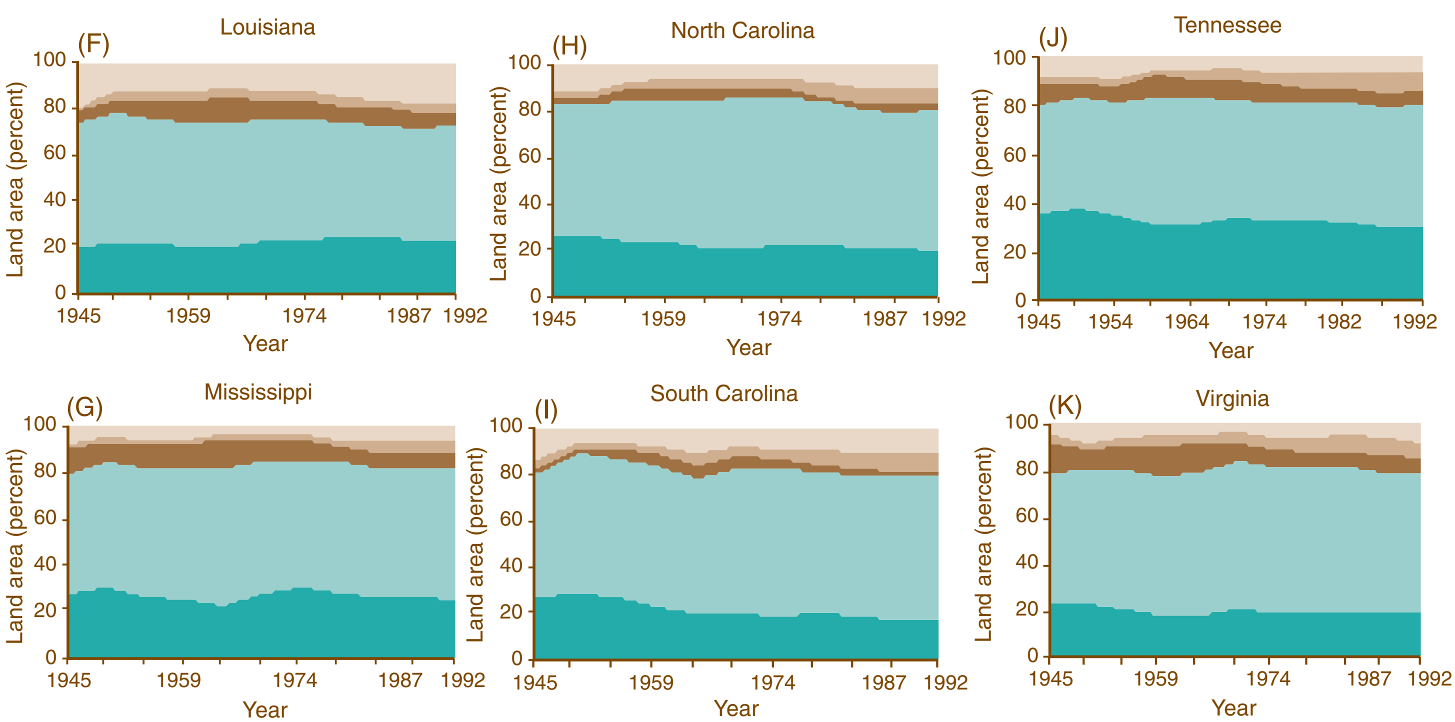


Figure 6.2—Area of land in crop, pasture, forest, and urban land uses for Southern States 1982 to 1997 (Texas and Oklahoma are not included in totals) [National Resource Inventories (National Cartography and Geospatial Center 1998)].



the observed increase in urban land uses was concentrated in the five States along the Atlantic Coast from Virginia to Florida. These States all had more than 7 percent of their non-Federal land in urban uses (fig. 6.3). These States plus Tennessee had the highest growth in the percent of land in urban uses from 1982 to 1997. In these States, 3 to 6 percent of non-Federal land was developed over this period.

The preceding data describes net change in land use. There can be considerable offsetting changes between land uses that are not revealed by measures of net change. While we could not derive gross changes at the State level from the available NRI data, the 1997 NRI report indicates that 9.6 percent of all rural non-Federal land in the United States experienced a land use change between 1982 and 1997. That number is likely to be higher in the East, where the share of private lands is much higher than in other regions. Land use data from forest inventories described in chapter 16

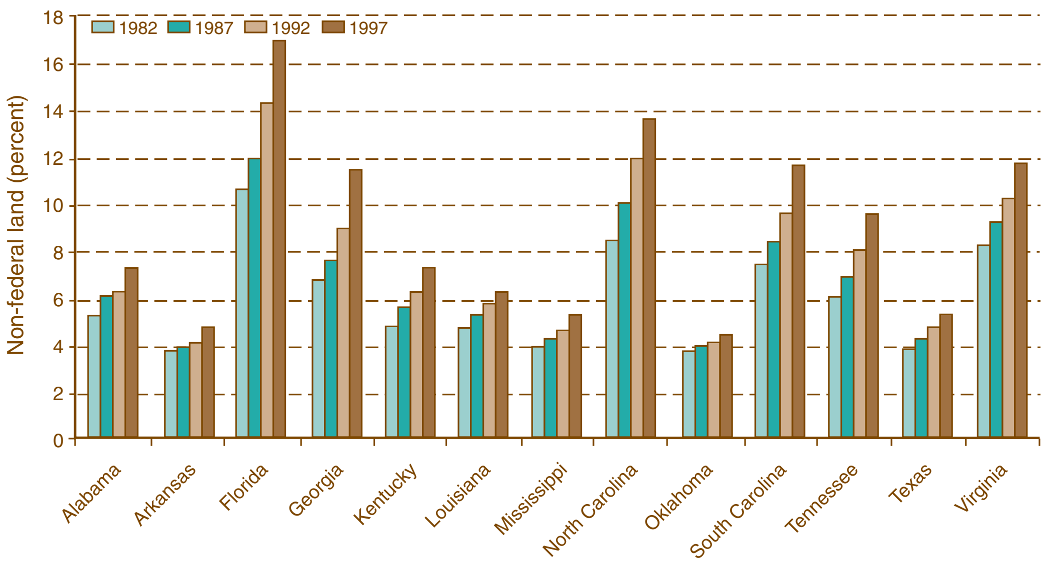


Figure 6.3—Percent of land in urban uses for Southern States 1982 to 1997 [National Resource Inventories (National Cartography and Geospatial Center 1998)].

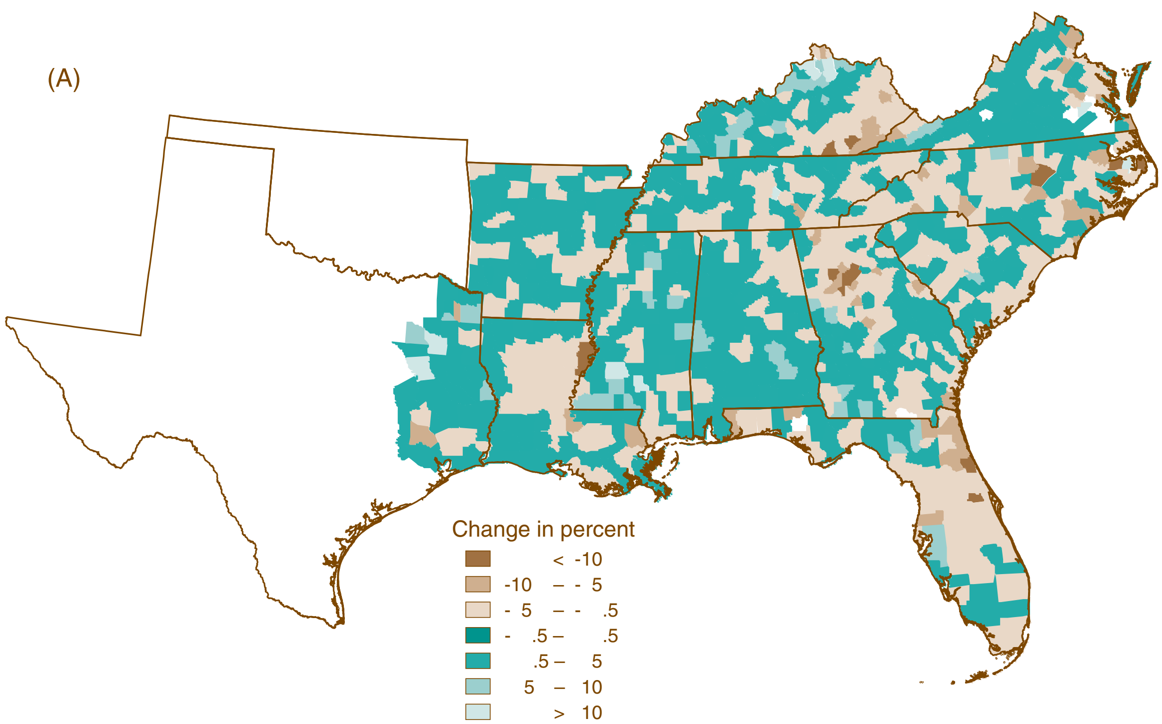


Figure 6.4—Changes in percent of (A) forest, (B) urban, and (C) agricultural land uses by county for 1982 to 1992 [National Resource Inventories (National Cartography and Geospatial Center 1998)].

reveal that over the past 20 years 2 to 3 million acres per year experience a change either from forest to nonforest or vice versa. These changes imply a significant impact on the condition of forests and their ability to provide wildlife habitat (see chapter 3), recreation (chapter 11), and environmental amenities (chapter 12).

County-level land use changes— County-level data show that major changes in land use occurred between 1982 and 1992 even though many Statewide totals were essentially unchanged (fig. 6.4). Forest area in southern and central Alabama and Mississippi rose at the expense of agricultural uses (figs. 6.4A and 6.4C). Similar shifts toward forest occurred in the upper Coastal Plain of South Carolina and Georgia, in northern and western Kentucky, and in western Tennessee.

Loss of forest land was generally concentrated in areas of rapid population growth and urbanization. Population growth was most substantial around Atlanta, GA, Washington, DC, Richmond, VA, Raleigh and Charlotte, NC, Nashville, TN, Charleston, SC,

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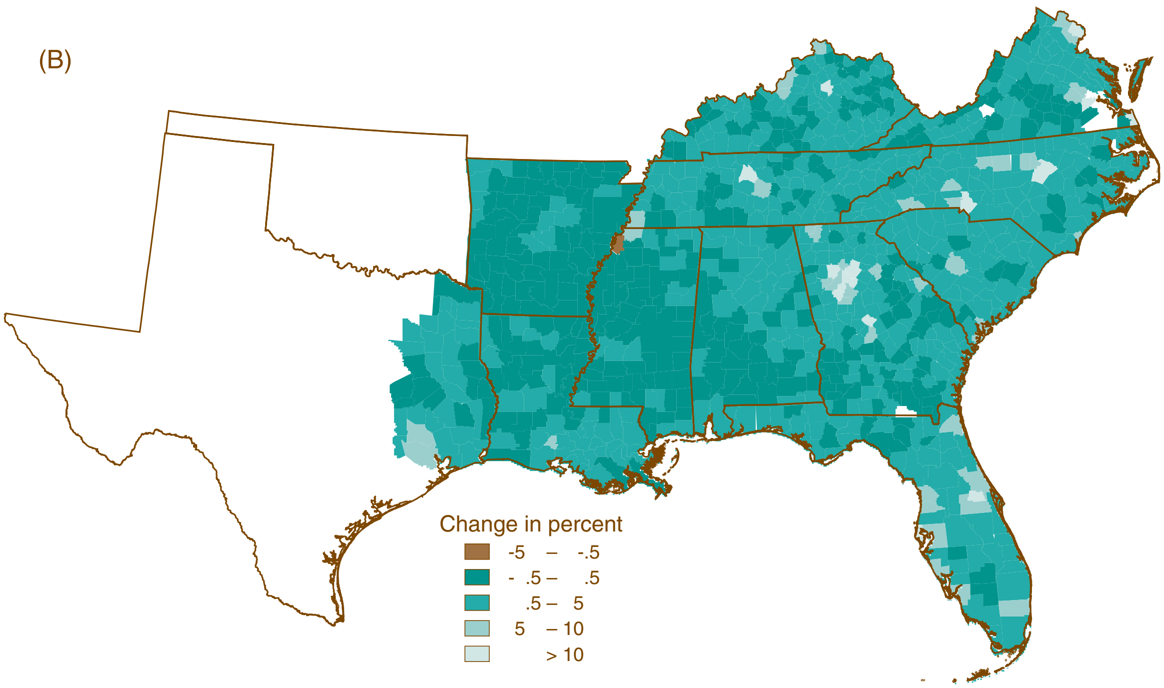
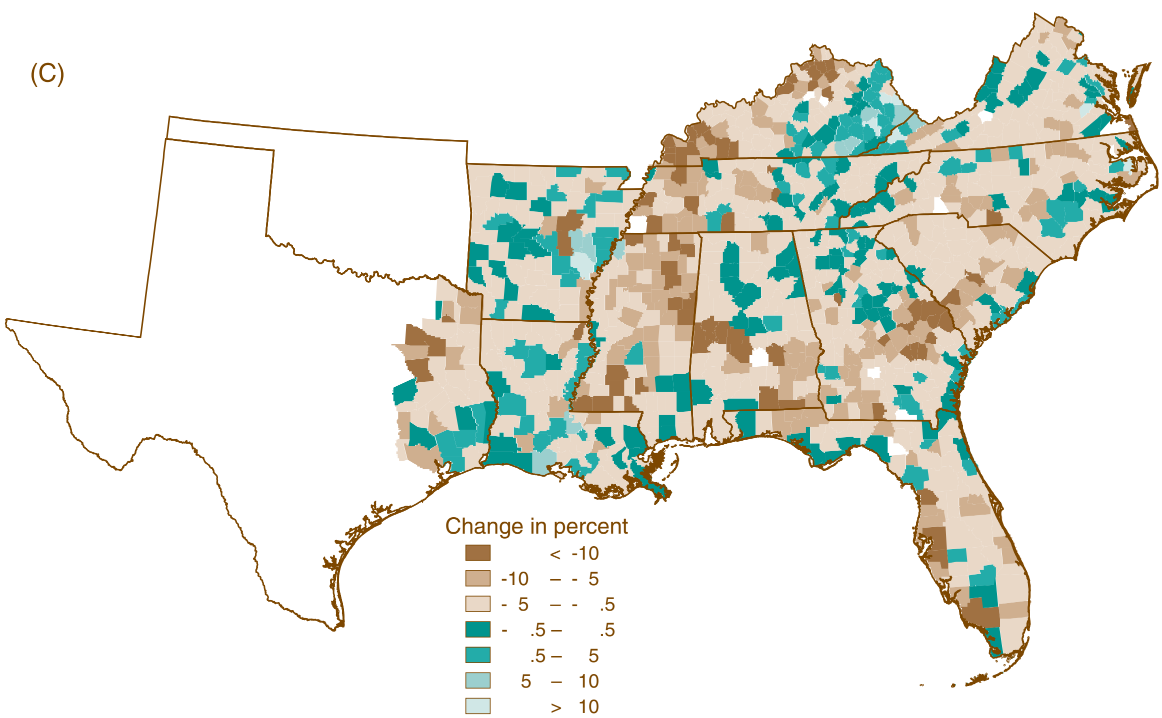
(B)



(C)



and the coastal cities of Florida. Some forest loss was also associated with expanding agricultural uses in east-central Arkansas and in parts of Kentucky, Louisiana, and North Carolina.

These county-level changes were aggregated to measure change by ecological section of the South. Forest loss was concentrated in the eastern part of the region (fig. 6.5) (table 6.2). The Florida Coastal Lowlands and the Atlantic Coastal Flatlands—essentially the Atlantic Coast of the South—had the highest percentage losses of forest land (3.7- and 2.6-percent loss, respectively). The Southern Unglaciated Allegheny Plateau, the Northern Cumberland Plateau, and the Southern Ridge and Valley also experienced relatively high losses. Another large contiguous block that includes the Northern Cumberland Mountains, the Mid-Atlantic Coastal Plain, the Blue Ridge Mountains, and the Southern Appalachian Piedmont lost more than 600,000 acres of forest.

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Table 6.2—Change in the percent of area in forest and amount of forest area by ecological section, 1982-92[a]

Ecological section	Change	
	Acres	*Percent*
Florida Coastal Lowlands (Eastern)	-183,100	-3.72
Atlantic Coastal Flatlands	-362,156	-2.58
Southern Unglaciated Allegheny Plateau	-36,900	-2.13
Northern Cumberland Plateau	-178,900	-2.09
Southern Ridge and Valley	-72,500	-1.74
Northern Cumberland Mountains	-23,200	-1.45
Middle Atlantic Coastal Plain	-83,900	-1.27
Blue Ridge Mountains	-152,500	-1.16
Southern Appalachian Piedmont	-492,500	-1.12
Mississippi Alluvial Basin	-220,800	-0.91
Central Ridge and Valley	-29,500	-0.90
Southern Cumberland Mountains	-19,800	-0.83
Ouachita Mountains	-29,600	-0.82
Everglades	-34,026	-0.65
Coastal Plains and Flatwoods, Western Gulf	-29,600	-0.41
Arkansas Valley	-9,500	-0.25
Boston Mountains	-7,400	-0.21
Louisiana Coast Prairies and Marshes	-11,400	-0.15
Coastal Plains and Flatwoods, Lower	-81,900	-0.15
Ozark Highlands	-7,500	-0.14
Florida Coastal Lowlands (Western)	6,900	0.12
Southern Cumberland Plateau	6,900	0.13
Upper Gulf Coastal Plain	16,800	0.24
Interior Low Plateau, Highland Rim	68,200	0.40
Northern Ridge and Valley	30,900	0.41
Central Gulf Prairies and Marshes	5,100	0.46
Mid Coastal Plains, Western	274,900	1.16
Eastern Gulf Prairies and Marshes	18,300	1.90
Coastal Plains, Middle	795,600	2.13
Interior Low Plateau, Shawnee Hills	128,900	2.66
Interior Low Plateau, Bluegrass	224,600	3.69
Oak Woods and Prairies	197,200	3.97
Total	-292,382	

[a] Entries are sorted by change in percent from largest loss to largest gain. Data were developed by aggregating county-level observations for forest land use from the National Resource Inventory into their respective ecological sections as defined by Rudis (1999).

Forest gains between 1982 and 1992 were concentrated mainly in the western half of the South, especially the middle Coastal Plain of Alabama and Mississippi. On the western side of the Mississippi River, gains were recorded in the Interior Lowland Plateau, the oak woods and prairies, and the eastern gulf prairies and marshes.

Driving variables: agricultural land rent—Changes in the relative values of agricultural and forest land uses can cause shifts from one use to another (Alig 1986). To measure change in agricultural returns, we examined farm rents for the period 1960 to 1994. Figure 6.6 shows rents for five States in the South that are typical of patterns for all others in the region. It shows that real agricultural rents declined in the South in the 1980s but does not show the variation that occurs within a State where specific rents depend on local site factors.

Driving variables: timber prices—Timber prices have also changed substantially over the last 30 years. Figure 6.7 shows that both pulpwood and sawtimber prices increased rapidly between 1970 and 1980, declined in the early 1990s, and then rose again through the late 1990s. Between 1986 and 1996 the real price of pulpwood increased by about 50 percent, while the real price of softwood sawtimber more than doubled. These changes translated into rising timber rents. As a result, we can infer that the agriculture-to-forestry rent ratio has fallen markedly from the mid-1980s on.

Driving variables: population—A critical determinant of the amount of forest in a county is its population density. Population of the South has grown steadily between 1940 and 2000 (fig. 6.8). Since 1980, the region's growth has outpaced the growth in the U.S. population as a whole, indicating an increase in the share of the Nation's population living in the South. Between 1970 and 2000, the share of the U.S. population in the 13 States of the Assessment area grew from 27 to 33 percent.

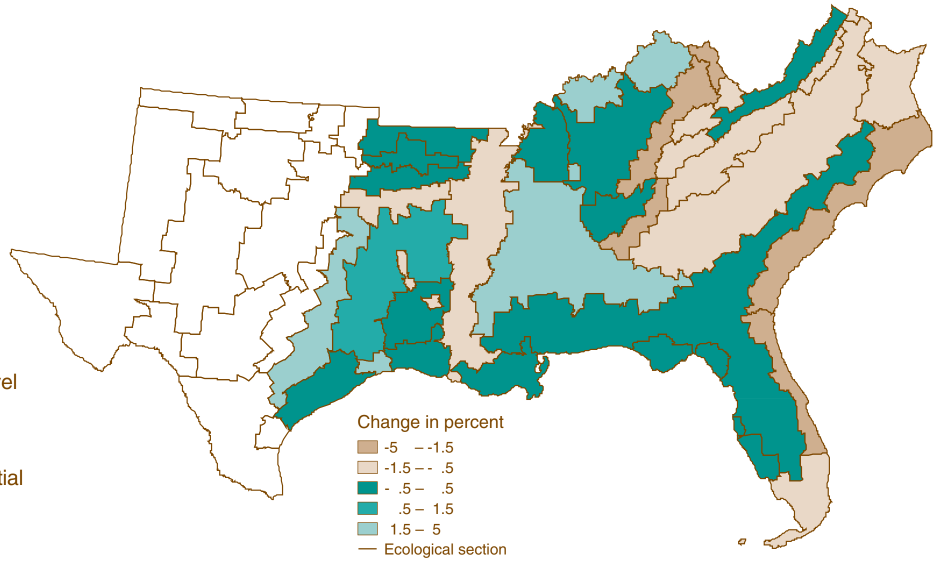


Figure 6.5—Summary of county-level changes in percent forest area by ecological section in the South [National Resource Inventories (National Cartography and Geospatial Center 1998), county aggregation according to Rudis (1999)].

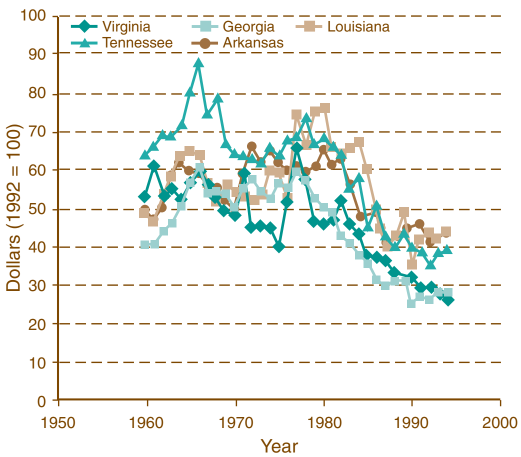


Figure 6.6—Agricultural rents for 1960 through 1994 for Virginia, Tennessee, Georgia, Arkansas, and Louisiana [rents are adjusted for inflation by the gross domestic product price deflator (1992 = 100)] (Jones 1997)].

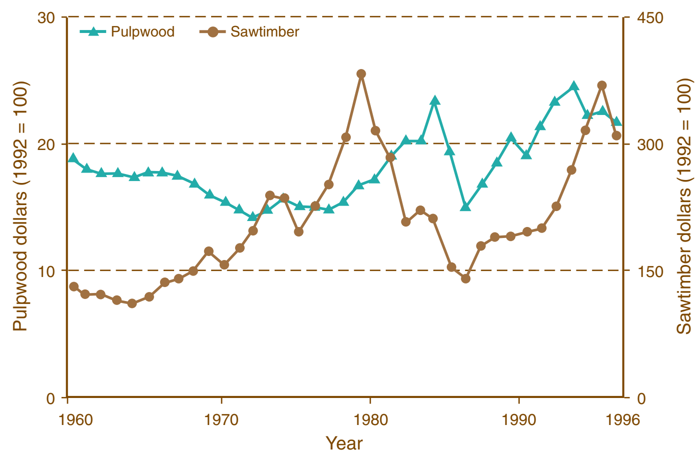


Figure 6.7—Real prices paid for softwood pulpwood and sawtimber in Louisiana, 1960 to 1996. Prices are adjusted for inflation by the gross domestic product price deflator (1992 = 100) [Louisiana severance tax records as reported in Ulrich (1987) and Howard (1999)].

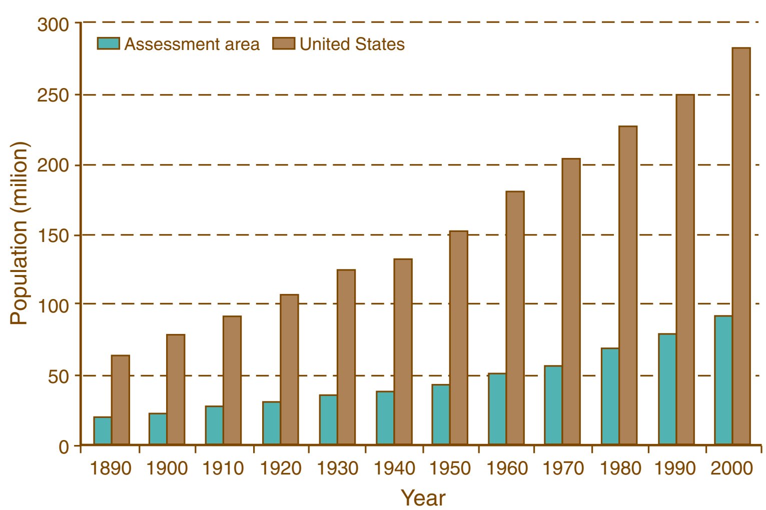


Figure 6.8—Population for the United States and for the 13 States in the Assessment area from 1890 to 2000 (U.S. Census Bureau 2002).

Growth in population has not been uniform across space or across time. Population growth between 1950 and 2000 was concentrated in the Southern Appalachian Piedmont and along both the Atlantic and gulf coasts (fig. 6.9A). Population density declined in rural portions of the Coastal Plain in Alabama, Mississippi, Arkansas, and Georgia. While population generally declined in rural areas and increased in urban areas in the 1960s (fig. 6.9B), by the 1990s nearly every county in the South was experiencing some population growth (fig. 6.9C).

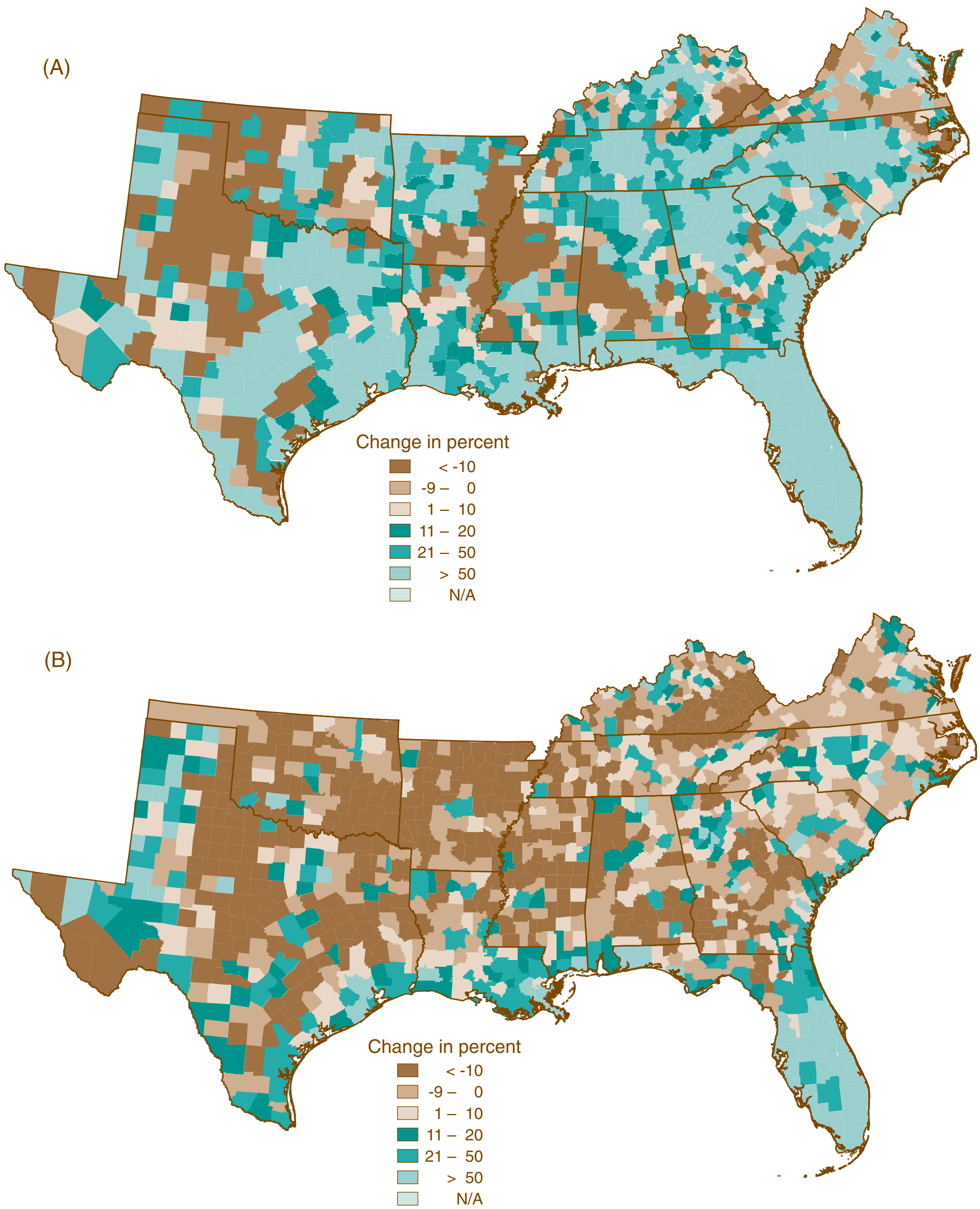
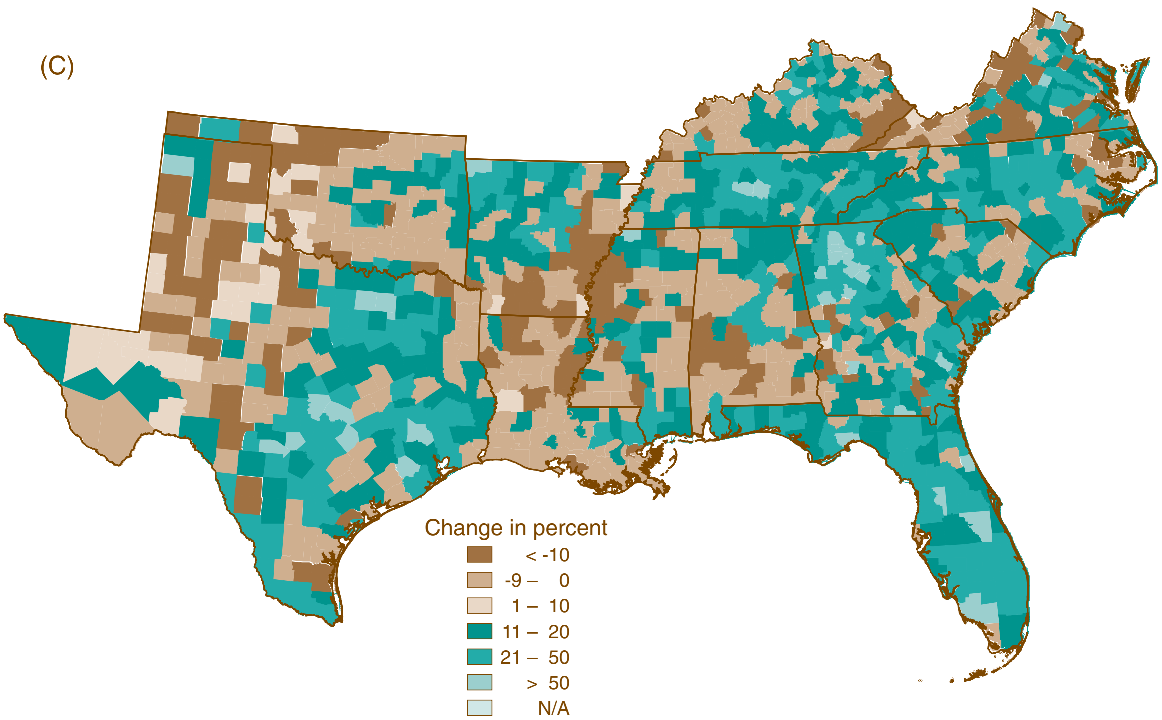


Figure 6.9—Percent changes in the density of population for (A) 1950 to 1999, (B) 1950 to 1960, and (C) 1990 to 1999 (U.S. Census Bureau 2002).

Land Use Forecasts

Urban growth scenario—The urban growth scenario evaluates potential changes in land use driven by anticipated changes in population, personal income, and housing values in the South. Relative returns from agricultural and forestry uses are held constant at their 1992 values. The focus, therefore, is on changes in the factors that influence the distribution of land between urban and rural uses. Forecasts were made for 2020 and 2040 and examined in detail for 2020.

The urban growth scenario indicates a growth in urban area from about 20 million acres in 1992 to 55 million acres in 2020 and to 81 million acres in 2040 (fig. 6.10). Without price adjustments in rural land markets (addressed later), land would shift out of agricultural, forest, and other uses. Forest area declines by about 12 million acres, agriculture by about 13 million acres, and other by about 7 million acres.



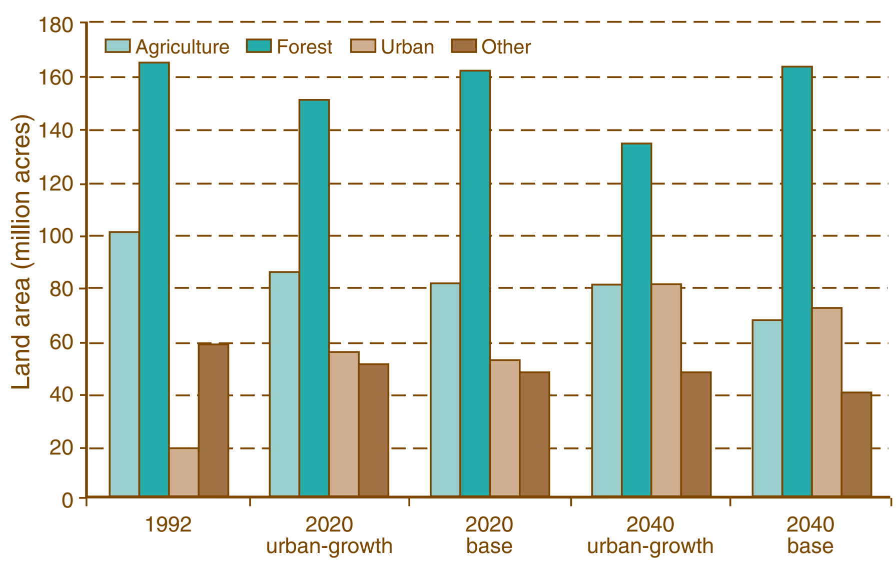


Figure 6.10—Areas of land in agriculture, forest, urban and other in 1992 and for four forecast scenarios [land use forecasting model described in Hardie and others (2000)].

In the forecast for 2020, substantial population and income growth are projected for about one-third of the region's counties. Urbanization is concentrated in three large areas (fig. 6.11): (1) the Southern Appalachian Piedmont stretching from Raleigh/Durham, NC, through Atlanta, GA; (2) the Atlantic Coast from the Carolinas through Florida; and (3) a portion of the gulf coast centered on Mobile Bay. Other centers of expanding urbanization are around Nashville and Knoxville, TN, and in northern and eastern Virginia.

Urbanization dominates rural land use, reducing the areas of both agricultural and forestry uses. Especially large losses of agricultural land are anticipated in Florida, central Tennessee, and central North Carolina (fig. 6.11B).

Losses of forest land are concentrated in areas of expected urbanization (fig. 6.11C). The Southern Appalachian Piedmont of the Carolinas and Georgia, central Tennessee, and Florida all are expected to experience substantial losses of forest land in response to population and income change.

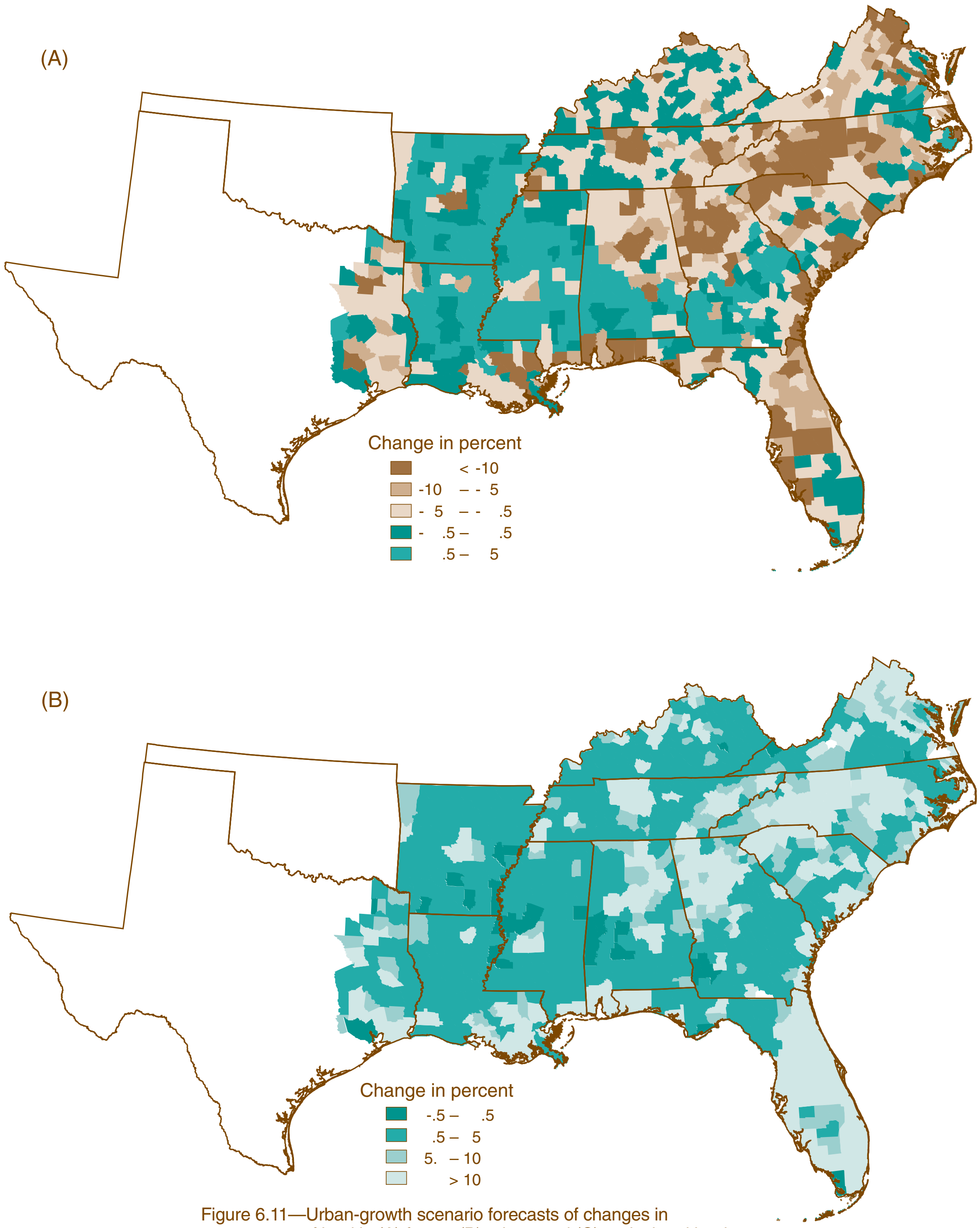
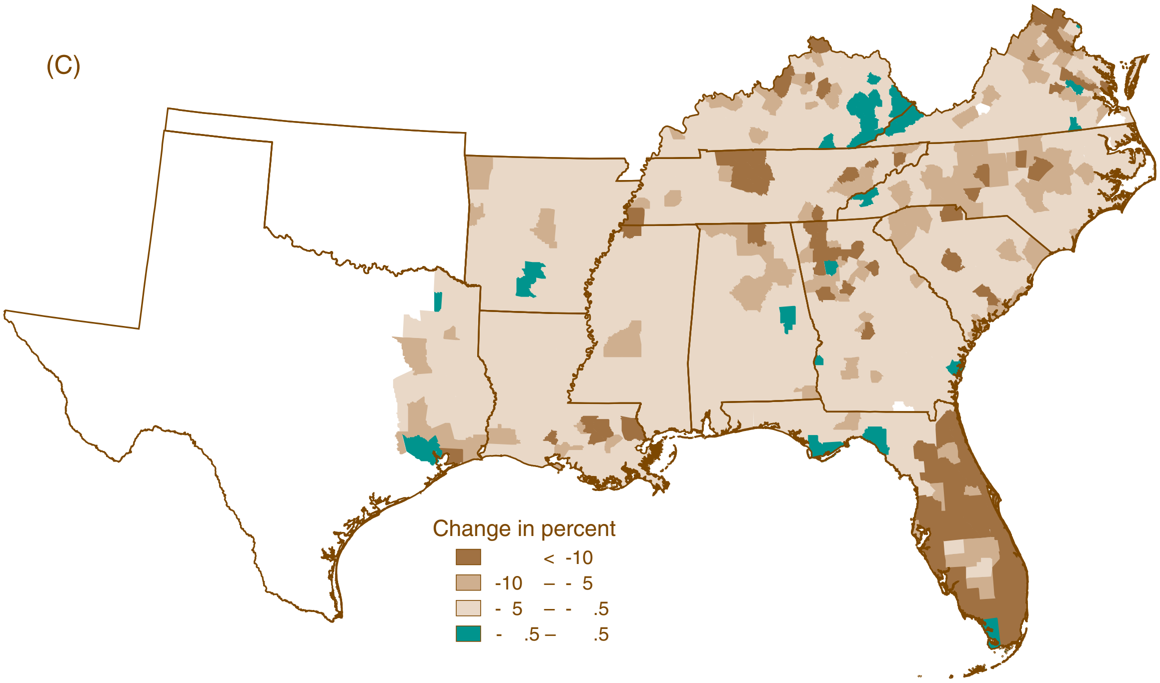


Figure 6.11—Urban-growth scenario forecasts of changes in percentages of land in (A) forest, (B) urban, and (C) agricultural land uses by county for 1992-2020 [land use forecasting model described in Hardie and others (2000)].

(C)



Mapping changes in land use by ecological section shows that forest loss will generally be concentrated in the eastern half of the South. The ecological section with the greatest loss will be the Southern Appalachian Piedmont. Figure 6.12 again shows forest losses would be high along the entire Atlantic Coast and the gulf coast of Florida. The largest contiguous block of forest loss will include the Southern Appalachian Piedmont, the Blue Ridge Mountains, the Ridge and Valley, and the Southern Cumberland Plateau.

Base scenario—The base scenario shows how the urban growth scenario would be altered if timber rents continued to increase relative to agricultural rents consistent with the timber base modeling in chapter 13. A 35-percent increase in real forest rent relative to real agricultural rent is forecast for 2020; a 75-percent increase is forecast for 2040.

The expected increase in timber prices has two effects shown by comparing the urban growth and base scenarios. One is to dampen slightly the demand for land in urban uses. As a result, urban land is forecast to be at about

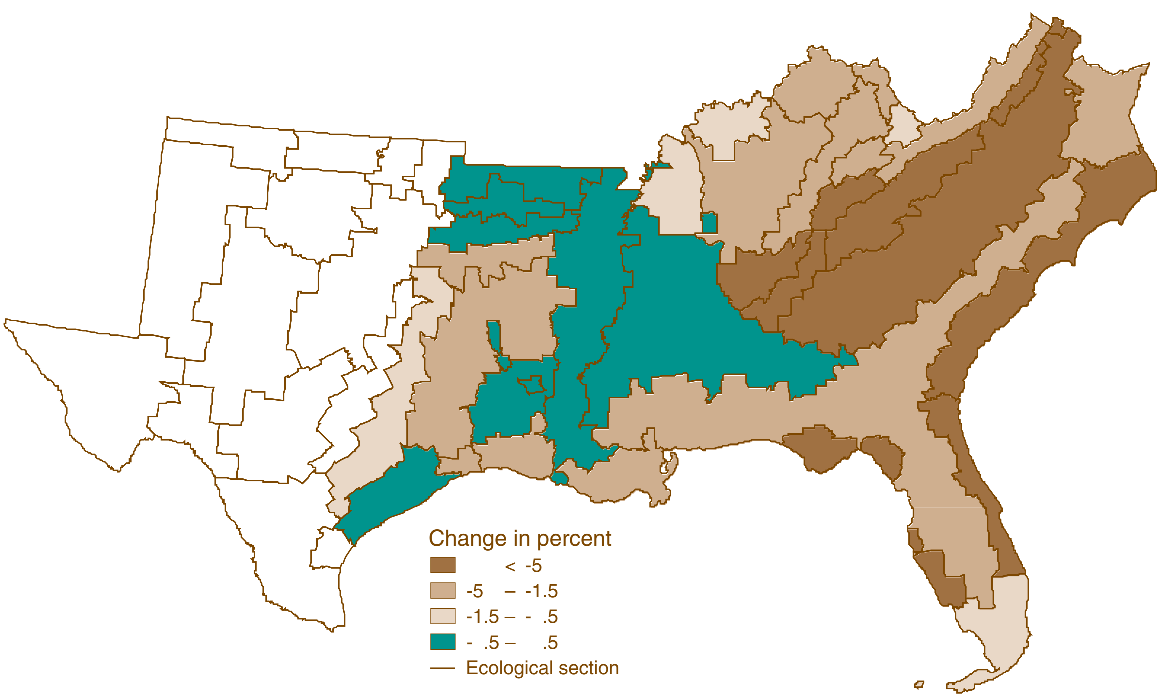


Figure 6.12—Forecast changes in percent of forest by ecological section for 1992 to 2020 under the urban-growth scenario [land use forecasting model described in Hardie and others (2000), county aggregation according to Rudis (2000)].

52 million acres rather than 55 million acres in 2020 and at 72 million acres rather than 81 million acres in 2040. The other effect is that some agricultural land would be planted to forest cover. Roughly 8 million acres would be planted by 2020 and 23 million acres by 2040 (fig. 6.10). The estimate of planting area is the difference between the areas of agricultural land use for the urban growth and base scenarios. The net effects are: (1) urban area expands, (2) forest change is nil, and (3) agricultural and other land declines. Consistent with history, gross changes among land uses would continue to be substantial.

The increase in timber prices leads to shifts from agriculture to forest in the South in 2020. Certain areas of the South may be especially sensitive to these changes (fig. 6.13). In the eastern half of the region, two areas show an increase in forest area. One is a small area in the upper Coastal Plain centered on the border between North Carolina and Virginia. The other is the entire upper Coastal Plain of Georgia and parts of the Coastal Plain of South Carolina. These findings are consistent with a recent study by Ahn and others (2001), who also found the potential for gains in forest land in spite of urban pressures in the western half of the South.

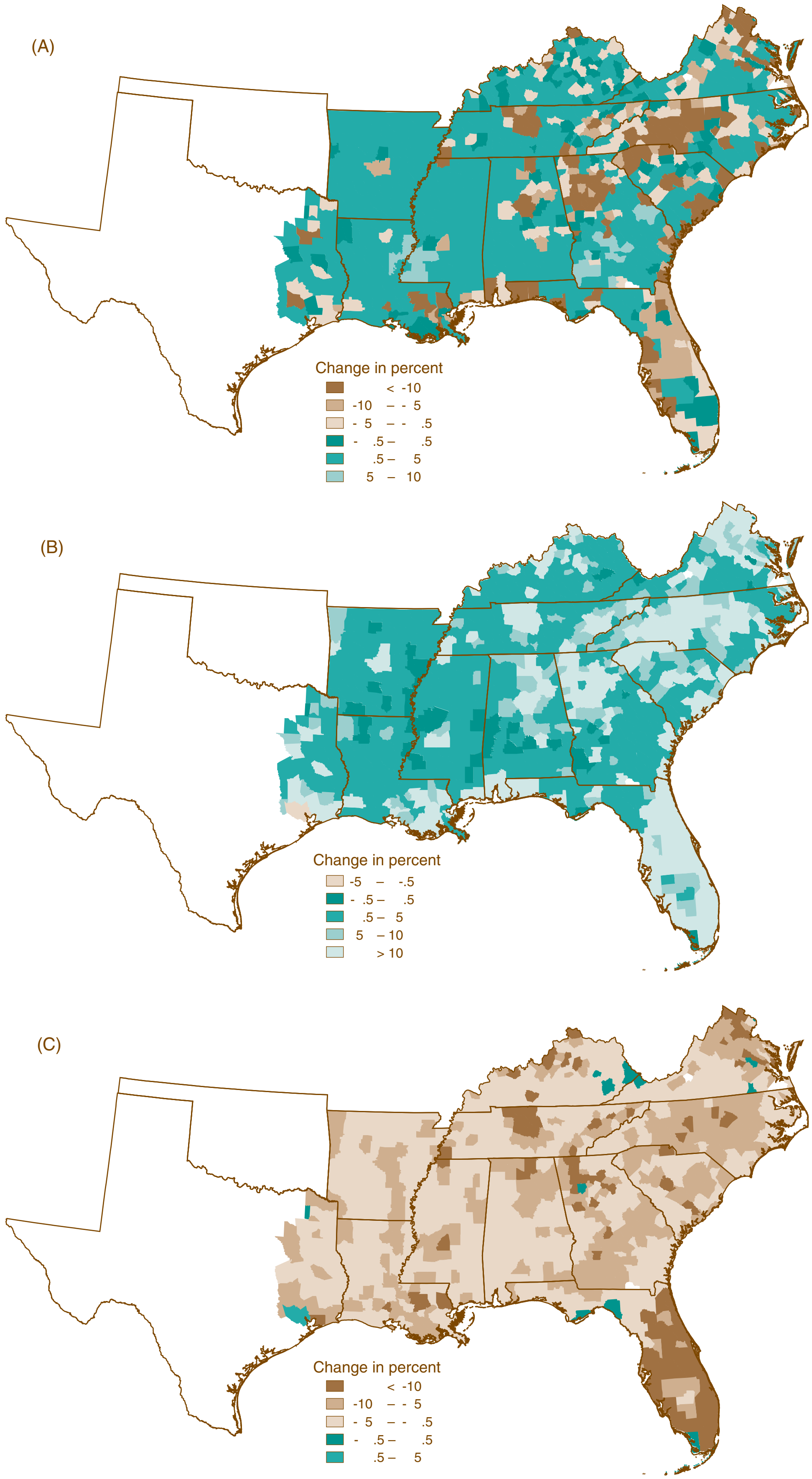


Figure 6.13—Forecast changes in percent under the base scenario of (A) forest, (B) urban, and (C) agricultural land uses by county for 1992 to 2020 [land use forecasting model described in Hardie and others (2000)].

Table 6.3—Change in the percent of area in forest and amount of forest area by ecological section, 1992-2020[a b]

Ecological section	Change	
	Acres	*Percent*
Southern Appalachian Piedmont	-3,508,238	-7.95
Southern Ridge and Valley	-298,941	-7.17
Atlantic Coastal Flatlands	-746,238	-5.32
Blue Ridge Mountains	-655,402	-4.98
Florida Coastal Lowlands (Eastern)	-230,977	-4.70
Central Ridge and Valley	-152,335	-4.63
Florida Coastal Lowlands (Western)	-205,895	-3.69
Southern Cumberland Plateau	-187,877	-3.46
Eastern Gulf Prairies and Marshes	-19,195	-2.00
Interior Low Plateau, Highland Rim	-338,960	-1.99
Northern Ridge and Valley	-126,901	-1.70
Interior Low Plateau, Bluegrass	-95,613	-1.57
Everglades	-54,216	-1.18
Coastal Plains and Flatwoods, Lower	-132,656	-0.24
Southern Unglaciated Allegheny Plateau	-3,891	-0.22
Southern Cumberland Mountains	-725	-0.03
Middle Atlantic Coastal Plain	-1,451	-0.02
Mid Coastal Plains, Western	30,829	0.13
Northern Cumberland Plateau	12,039	0.14
Northern Cumberland Mountains	5,525	0.43
Louisiana Coast Prairies and Marshes	32,686	0.44
Interior Low Plateau, Shawnee Hills	22,225	0.46
Ouachita Mountains	21,625	0.60
Upper Gulf Coastal Plain	73,832	1.07
Central Gulf Prairies and Marshes	15,306	1.38
Oak Woods and Prairies	97,270	1.96
Coastal Plains, Middle	1,149,225	3.08
Arkansas Valley	122,764	3.28
Ozark Highlands	197,008	3.55
Mississippi Alluvial Basin	872,002	3.61
Boston Mountains	130,610	3.64
Coastal Plains and Flatwoods, Western Gulf	277,915	3.89
Total	-3,698,650	

[a] Forecasts are for the base scenario (population, income, and housing forecasts along with a 35-percent price increase).
[b] Entries are sorted by change in percent from largest loss to largest gain. Data were developed by aggregating county-level observations for forest land use from the National Resource Inventory into their respective ecological sections as defined by Rudis (1999).

However, the largest block of potential gain in forest land would lie in the western one-third of the South. This area includes the southwestern quadrant of Alabama and nearly the entire States of Mississippi, Louisiana, and Arkansas. In this area, rural land use appears to be very sensitive to changes in relative returns to agricultural and forestry (fig. 6.14) (table 6.3).

As significant as the areas showing gains in forest area is a large contiguous portion of the region showing little response to increasing forest rent. This area reaches from the northern parts of South Carolina, Georgia, and Alabama to the northern boundary of the Assessment area.

Sensitivity analysis—A sensitivity analysis of the effect of timber price changes shows that the margin between agricultural and forest land uses could be relatively flexible. The urban growth scenario forecast a loss of about 12 million acres of forest land; the scenario with a 10-percent increase in real timber prices forecast a loss of about 8 million acres. If the real timber price were to increase by 20 percent from 1992 to 2020, forest land loss is forecast to be 3.5 million acres. A 30-percent real price increase results in essentially no net change in forest land in the South.

This sensitivity analysis has focused on upward movement in the timber-to-agriculture rent ratio. If this rent ratio were to fall—if agriculture rents rise relative to timber—we would expect the reverse. Forest land would move toward agricultural uses at the margin.

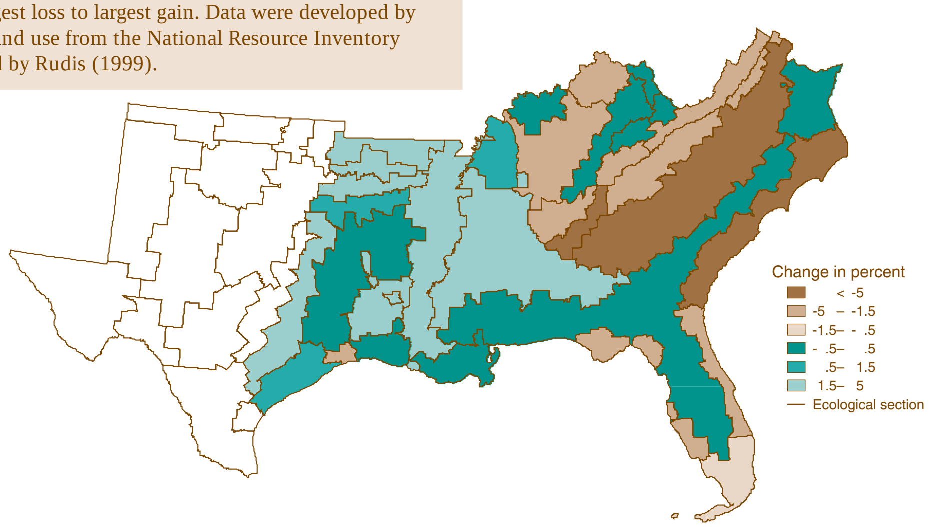


Figure 6.14—Forecast changes in percent of forest by ecological section for 1992 to 2020 under the base scenario [land use forecasting model described in Hardie and others (2000), county aggregation according to Rudis (2000)].

Forest Conditions

Forest population density—Forest population density (FPD) measures the number of people per square mile (ppsm) of forest in counties. The index ranges from about 20 ppsm in very rural areas of the South to more than 1,000 in urbanized areas. We consider 1,000 ppsm a "saturated" condition and cap FPD values at 1,000. As expected, FPD is highest near large cities (fig. 6.15A). Florida has the highest concentration of these saturated areas. Population density is very high throughout Florida, and forest cover is low in the southern half of the State. The largest contiguous area of very low FPD is in southwestern Alabama, where more than 20 counties have an FPD of less than 50 ppsm.

Three areas of the South with interstate highway corridors had relatively high FPD values in 1992: the Interstate-85 corridor from Raleigh/Durham, NC, to Atlanta, GA; the Interstate-65 corridor from Birmingham, AL, to Nashville, TN; and the Interstate-81 corridor from Chattanooga, TN, to Wytheville, VA. On the periphery of the region in northern Kentucky and Virginia and along the gulf coast, FPDs were also relatively high in 1992.

Forecasts to 2020 indicate continued outward growth of the urban centers of the South. A characteristic "doughnut" pattern of growth emerges around the cities of Atlanta, GA, Nashville, TN, Charlotte, NC, and Washington, DC (fig. 6.15B). Expansion in FPD would also be concentrated along the Atlantic Coast in South Carolina and Florida and along the gulf coast. Figure 6.16 shows the shift in the population profile of counties in the South. There is a strong movement to the right as 82 counties move out of the most rural category (FPD = 0 to100 ppsm) and 52 counties move into the saturated category (greater than 900 ppsm).

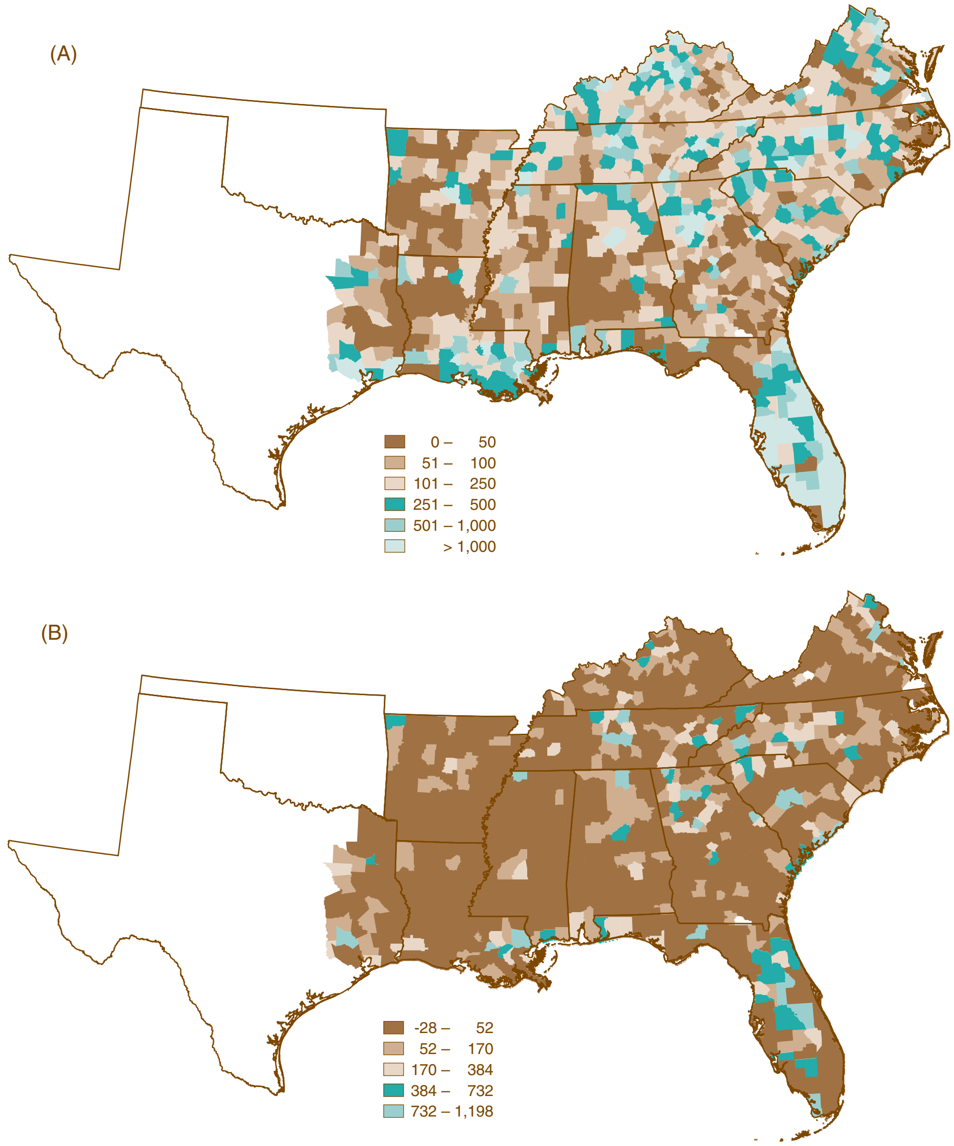


Figure 6.15—Forest population density index (FPD) in (A) people per square mile of forest by county for 1992 and (B) change in FPD for 1992 to 2020 [1992 forest land use from the National Resources Inventory (National Cartography and Geospatial Center (1998); 2000 forest use from the land use forecasting model described in Hardie and others (2000); population in 1992, U.S. Census Bureau (2002); and population in 2020 from county-level forecasts by NPA Data Service Inc. (1999)].

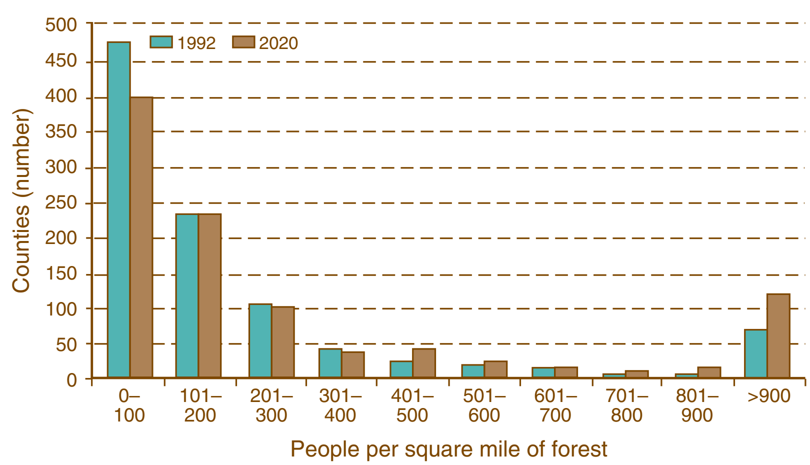


Figure 6.16—Numbers of counties in forest population density index classes, 1992 and 2020 [1992 forest land use from the National Resources Inventory (National Cartography and Geospatial Center (1998); 2000 forest use from the land use forecasting model described in Hardie and others (2000); population in 1992, U.S. Census Bureau (2002); and population in 2020 from county-level forecasts by NPA Data Service Inc. (1999)].

Landscape patterns—Maps of landcover in the early 1990s (fig. 6.17) reveal that, overall, the South is heavily forested and that the distribution of forest cover is highly variable. Two areas of the South have large blocks of counties with forest cover in excess of 80 percent of the landscape. One is the Blue Ridge Mountain Province from northern Georgia to the North Carolina-Virginia border. The other is the Cumberland Plateau/Southern Allegheny region stretching from central Tennessee (just west of Knoxville) to the Ohio River.

Areas with somewhat less forest cover than the Blue Ridge, but still substantial shares, are the Southern Appalachian Piedmont and the Gulf Coastal Plain (including nearly the entire State of Alabama). Even in the urbanizing areas of the Southern Appalachian Piedmont, forest covers a majority of the land. The other area of substantial contiguous forest cover is west of the Mississippi River in a block that stretches north from central Louisiana to the Ozark Mountains.

Forest cover does not dominate in important agricultural areas of the South. Agriculture is especially dominant in the Mississippi Alluvial Valley, in the northern and western portions of Kentucky, and in the southwestern corner of Georgia (fig. 6.17B).

Developed human uses are especially high in two areas. One is the Piedmont crescent stretching from Raleigh/Durham, NC, to Atlanta, GA. The other is peninsular Florida. Other areas with substantial clusters of urban cover are Nashville and Knoxville, TN, and Washington, DC. All of these cities are surrounded by relatively large "footprints" of urban use.

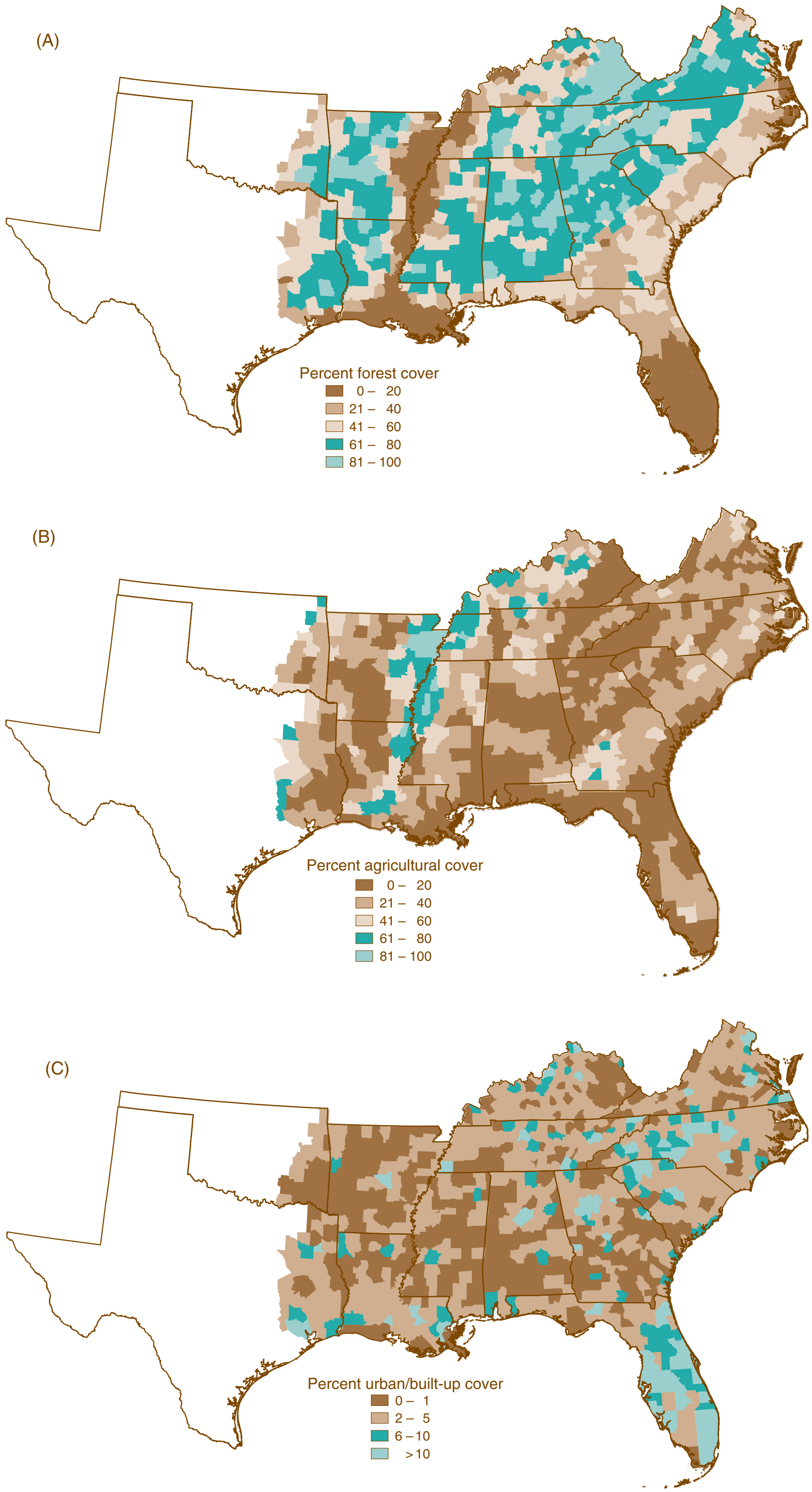


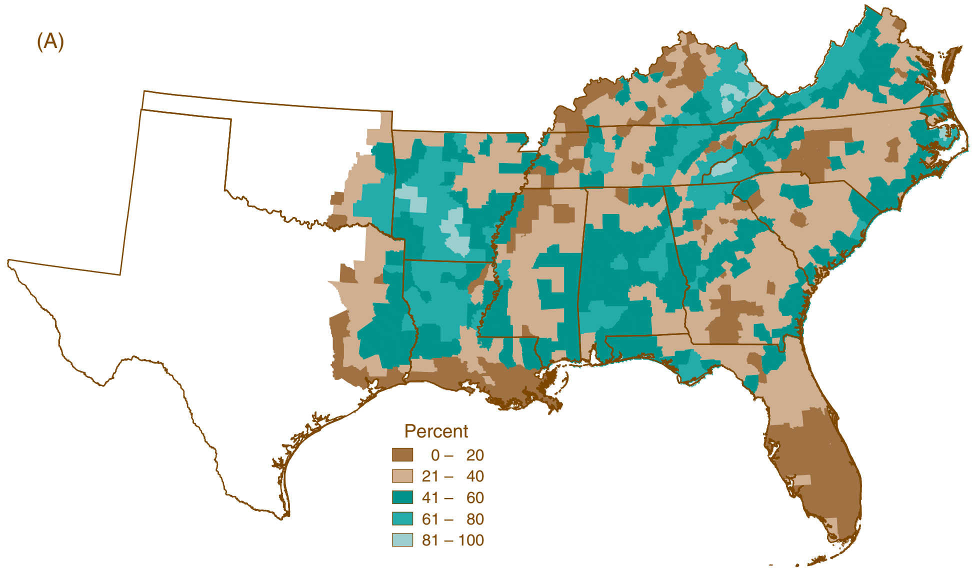
Figure 6.17—Shares of areas in southern counties in 1992 in: (A) forest, (B) agriculture, and (C) urban [Multi-Resolution Land Characteristics land-cover maps (Vogelmann and others 1998)].

A high proportion of interior forest in a county is an indicator of relatively contiguous forest. The highest concentrations of interior forest at the fine scale (7-ha neighborhood) are found in the Blue Ridge Mountains and in the Cumberland Plateau/Allegheny Mountain sections of the South (fig. 6.18A). The Great Smoky Mountains National Park and a part of the Daniel Boone National Forest in Kentucky (just west of where Virginia, West Virginia, and Tennessee meet) are the cores of these two areas. Other areas where the share of interior forest is high include the Ouachita Highland/Ozark Mountain region of Arkansas, a region just north of Mobile Bay, and the Apalachicola area in the Panhandle of Florida. All of these areas include relatively high shares of land in either public or forest industry ownership.

The broad-scale measure of interior forest (56-ha neighborhood) highlights the relative scarcity of large contiguous areas of forest cover. At this scale, blocks of interior forest are found only in far western Virginia, the Cumberland Plateau, the Blue Ridge, and the mid-Coastal Plain west of the Mississippi River.

Forests that are highly fragmented are shaped primarily by human influences. The Southern Appalachian Piedmont has a relatively high proportion of land in an edge-dominated category, especially in North Carolina (fig. 6.19). Two other contiguous blocks are in an area spanning northern Mississippi and western Tennessee and an area west of the Cumberland Plateau between Alabama and Cincinnati, OH. In both of these areas, agricultural cover types break up the forest cover into small patches and reduce the amount of interior forest.

(A)



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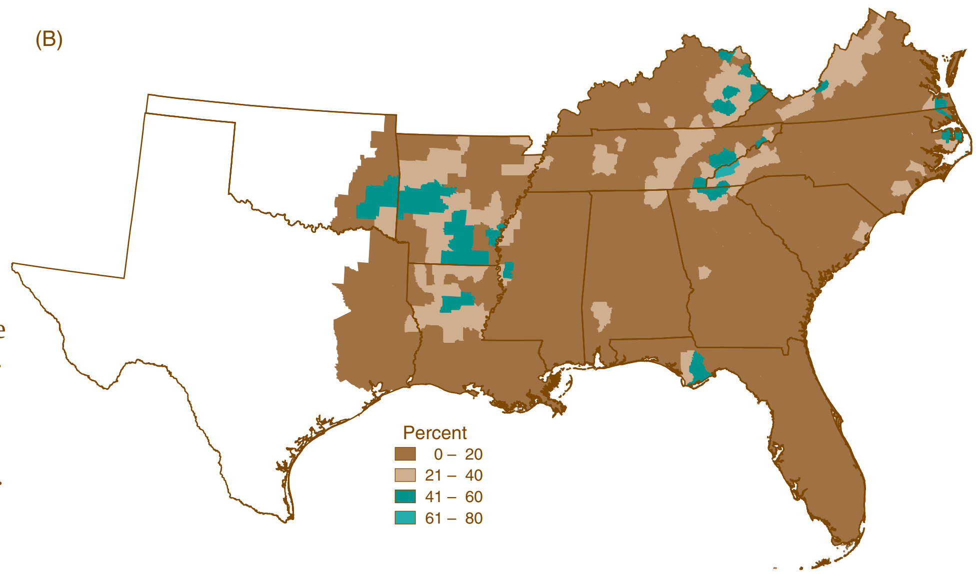

Figure 6.18—Shares of areas in counties classified as interior forest at (A) a fine scale (7-ha neighborhood), and (B) a broad scale (66-ha neighborhood) [Riitters and others (2000)].

Discussion and Conclusions

Compared to earlier periods, land use in the South has been fairly stable since 1945. The most notable exception is Florida, where developed land uses have expanded substantially. However, an evaluation of land use dynamics between 1982 and 1992 indicates that while total forest area has been stable, the stability is the result of substantial offsetting changes into and out of forest cover. As a result, much of the southern forest landscape has experienced significant change.

Two dominant forces strongly influenced recent land use changes: (1) urbanization driven by population and general economic growth and (2) changing relative returns to agriculture and timber production. We expect their influences to continue. As a result of anticipated population and economic growth, rural land will be converted to urban uses. As a result of increases in timber prices, some agricultural land will become forested. Depending on assumptions about future timber prices, forecasts of land uses indicate that the South could experience a net loss of from 8 to 12 million acres of forest land (roughly 5 to 8 percent) between 1992 and 2020.

Forest losses are likely to be concentrated in four areas: (1) the Piedmont and Mountain areas of North Carolina, (2) adjacent Piedmont areas of South Carolina and Georgia, (3) northern peninsular Florida, and (4) the Atlantic and gulf coastal areas. Other areas with substantial projected losses are around the cities of Nashville, TN, and Birmingham, AL, and in northern Virginia between Washington, DC, and Richmond, VA.

Gains in forest land at the expense of agriculture are likely in other regions of the South. In the eastern part of the

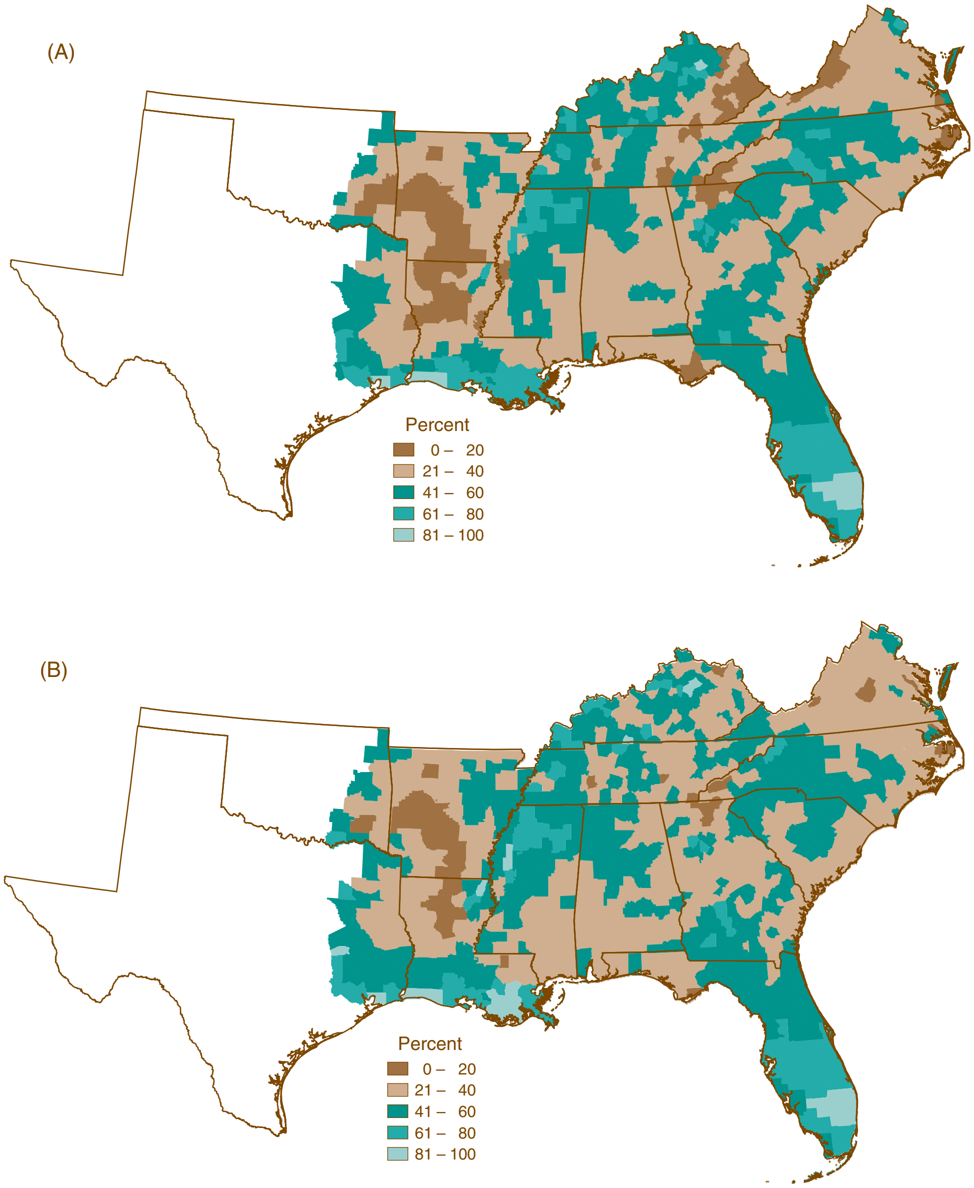

Figure 6.19—Shares of areas in southern counties classified as edge-dominated forest at (A) a fine scale (7-ha neighborhood), and (B) a broad scale (66-ha neighborhood) [Riitters and others (2000)].

South, forest gains are possible in two relatively small areas: (1) the upper Coastal Plain of Georgia and (2) an area centered on the boundary between North Carolina and Virginia in the Coastal Plain. In the western part of the South, forest gains are possible in the lower Gulf Coastal Plain in Alabama and in large portions of Arkansas, Mississippi, and Louisiana. Overall losses in forest in the eastern part of the region will likely be offset by gains primarily in the western part of the region.

This information may prove useful to policy analysts as they design afforestation policies. Cost-share programs such as the Forestry Incentives Program have long been popular conservation instruments in the United States. Our analysis suggests that certain areas are more prone to shift agricultural land to forest cover based on land quality and economics. Afforestation policies could be made more effective if they were targeted to these areas.

Forecasts of a forest population density index indicate that the potential influence of urban areas on forests extends far beyond city cores. As population density increases, so does the valuation and use of these forests. For example, forest benefits such as recreation and microclimate moderation increase in value in an urbanizing area. Timber management is generally inversely correlated with population density (Wear and others 1999). In these areas, therefore, timber harvesting is likely to be associated with land use conversions, and not with ongoing forest management. Another effect of urbanization is the division of large blocks of forests into smaller tracts or parcels. This increases the number of landowners, thereby complicating land management especially with regard to the use of fire.

While studies of growth and development tend to focus on urban areas, changes in population and forests are also occurring in the South's rural areas. As a result, the area in what has been called the "wildland-urban interface" is growing rapidly. Problems with interactions between people and forested systems therefore can also be expected to grow.

Evaluation of the spatial structure of forests identified parts of the South where the share of forest cover is relatively high but the forest is highly fragmented. This condition is especially common in some northern portions of the South, on the Southern Appalachian Piedmont, and in northern Florida. The effect of forest loss on habitat structure generally increases as the fragmentation of an area increases. In fragmented forests, small changes in the amount of forest cover may have disproportionate impacts on the connectivity of forested habitats (Turner and others 1989).

A synthesis of findings suggests several "hotspots" where changes in land use and forest conditions portend important negative impacts on the services provided by forests. They are:

- The Southern Appalachian Piedmont, especially along the Interstate-85 corridor between Raleigh/Durham, NC, and Atlanta, GA.
- The Blue Ridge Mountains in North Carolina.
- The Atlantic and gulf coastal areas.
- Northern peninsular Florida.

The same kind of effects are being concentrated in urbanizing areas surrounding the following cities:

- Nashville, TN
- Knoxville, TN
- Birmingham, AL
- Washington, DC

SOCIAL

Needs for Additional Research

The land use forecasting described here was conducted at the county level of resolution, a rather coarse grain. Additional information about the implications for terrestrial ecosystems and water quality and aquatic ecosystems could be developed from analysis at a finer scale. Fine-scale analysis has been conducted for small areas by Wear and Bolstad (1998) and Turner and others (1996). Studies such as these address land use and cover at a cell size as small as 0.09 ha and can therefore provide direct linkage between land use choices and local ecological structure and impacts. Extending this scale of analysis, while expensive, could provide valuable and much more direct insights into the links between human activities and ecological consequences.

Additional work that links social demographics with land use and resource management decisions could provide additional insights into how social change might influence the flow of goods and services from forested ecosystems.

Acknowledgments

Thanks to my colleagues Peter Parks and Ian Hardie for their work in developing the land use model used in the chapter. Thanks also to Kurt Riitters for compiling the MRLC data and to David Butry for constructing the maps.

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The southern forest resource assessment provides a comprehensive analysis of the history, status, and likely future of forests in the Southern United States. Twenty-three chapters address questions regarding social/economic systems, terrestrial ecosystems, water and aquatic ecosystems, forest health, and timber management; 2 additional chapters provide a background on history and fire. Each chapter surveys pertinent literature and data, assesses conditions, identifies research needs, and examines the implications for southern forests and the benefits that they provide.

Keywords: Conservation, forest sustainability, integrated assessment.